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ABSTRACT

Neither video technology nor computer technology has had the impact on formal education that many had predicted. Both media have enormous and growing potential for this purpose however. Instructional packages that can be used as supplementary material to teaching seems the most appropriate approach to develop for higher education. Video modules enlarge the audience for special material, make available inaccessible material, and perform self analysis and evaluation. Computer based modules offer interactive testing of accumulated knowledge, self-paced analysis and investigation, and gaming. The primary obstacles to the use of these technologies are the absence of a viable system for distribution and access, the limited technological resources of the schools, and the lack of adequate incentives for authors of such modules. One force acting to overcome these obstacles is EDUCOM. Since it was established in 1964, EDUCOM has attempted to help create a national computer network, provide information to improve computing services within individual universities and colleges, and provided a forum for higher education institutions to speak to the Federal Government on the subject of educational computing. (JY)

Modular Instructional Materials: Video and Computer Packages

Joe B. Wyatt

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With the development of radio and television and later, since the development of the early digital computers in the 1950's, people have used electronic technologies for learning. As communications technology has improved, the exposure of people to information processed and delivered via the technological media has reached most of the population of the United States.

Traditional education has relied heavily on personal contact between the teacher and the student. Prior to the advent of printing technology, personal verbalization and demonstration of concepts and ideas were the exclusive methods for educational communication. Printing technology brought with it the ability to establish indirect forms of contact. The distribution of carefully prepared printed material allowed a much more widespread dissemination of concepts and ideas where total personal contact was not required. Printing technology has had hundreds of years to become established as a means of delivering instructional material. Reading skills are emphasized from a very early age in order to maximize the effectiveness of printing technology. Printing technology has thus become an important and essential form of "leverage" for teachers to communicate material to students.

Electronic technology in the form of audio systems, video systems, and computer systems bring powerfully different forms of leverage. Although audio and video technology are passive, in a manner similar to books, they

have some inherent advantages over printed material. The leverage is similar to that of books but provides an important new perapective, e.g., sounds and sighta. Computer technology is different in that it is not passive. Through the use of stored program "software", digital computer syatems can be programmed to interact with people as well as perform feats of computation and information processing. Moreover, computer technology can be used in conjunction with the audiovisual and printing technologies. It is this concept that seems to have enormous potential.

TECHNOLOGY AND TEACHING

Currently, all of these technologies are being used at increasing rates to process and deliver information to people. For example, over the two decade period since 1950 the annual number of additions of printed matter at university libraries quadrupled on the average. At the same of expansion it will have multiplied sixteen fold from its 1950 level in two more decades.[1] Broadcast television (primarily as an entertainment medium) is now represented by television sets in over 90,000,000 American households. Over ten million of these television households are on cable television,[2] the medium which offers "two-way" communication capability and has promised to marry computer technology and audiovisual technology. As a part of this growth, instructional television (ITFS) stations are flourishing under licenses granted by the Federal Communications Commission. Also in the past two decades, the number of atored program digital computers in use in the United States has increased

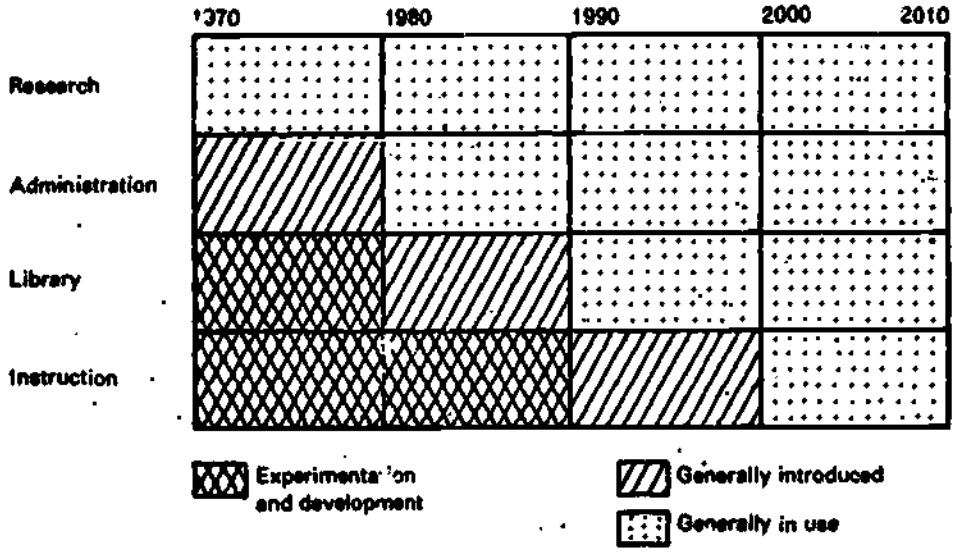
1. Baumol, Wm. J. and Marcus, Matityahu, Economics of Academic Libraries, American Council on Education, 1973, p 13.

2. "Cable Data", Cable Television Information Center, The Urban Institute, Washington, D.C., 1974.

from a handful to over 1 million with a near exponential growth rate that is continuing to increase. Thousands of these computer systems are in colleges and universities. Mini and micro computer technology promises to lower the cost and improve the versatility of computer based systems enough to accelerate this already explosive growth, e.g., programmable hand-held calculators.

One can argue that we have enormous technological power for teaching. We are not, however, using the power at a level approaching its potential. The non-classaical Carnegie Commission study indicates that the experience with technology (applied to instruction) as compared with the hopes of its early supporters suggesta that "it is a) coming along more slowly, b) coating more money, and c) adding to rather than replacing older approaches - as the teacher once added to what the family could offer, as writing then added to oral instruction, as the book later added to the handwritten manuscript".[3] The Carnegie work also concluded that the use of these technologies in instruction is substantially trailing the primary uses in universities which (in chronological order) have been research, administration and the library[4] (see Figure 1). Now, five years later, their predictions are not obviously overly pessamistic.

FIGURE 1 *Estimated use of electronic technology (computers, "cable" television, videocassettes) in higher education*



SOURCE: Staff of the Carnegie Commission on Higher Education.

3. The Fourth Revolution: Instructional Technology in Higher Education, Carnegie Commission on Higher Education, June, 1972.
4. Ibid p 2.

With the increase in the numbers of students in colleges and universities in the past two decades, educational principles as practiced in teaching have changed. The ratio of teaching faculty to students has become sufficiently small that there is often little opportunity for individual interaction between student and teacher, particularly at the undergraduate level. Students are taught by other students with diminished opportunities for informal encounters. Faculty teaching is further reduced by research, administrative appointments and other non-teaching activities. Adding to the problem are two important factors: the amount of knowledge which should be delivered to a student in the time period available continues to increase sharply, and the "financial crunch" in education is demanding more productivity of the teaching process.

TECHNOLOGY-BASED INSTRUCTIONAL PACKAGES

Neither video technology nor computer technology has had the impact on formal education that many had predicted. Both mediums have enormous and growing potential for this purpose, however. There are a number of factors affecting the use of instructional technology, and most have been thoroughly discussed before. The thesis of this work is that the concept of modular instructional packages which can be used as supplementary material to teaching is the most appropriate area to develop for higher education. The timing appears to be about right. Many of the opportunities are already indicated, but there continue to be obstacles as well. In the following paragraphs, some opportunities for the contribution of electronic technologies to teaching are discussed from the point of view of the modular instructional supplements. Also, some of the major obstacles are described in a prescriptive manner. Finally, the efforts and plans of EDUCOM which relate to these opportunities and problems are briefly introduced.

Video Modules

With the invention and widespread marketing of electronic video devices of small size and durable character, the magnetic film (videotape) medium has leapfrogged and expanded the role of its photographic film predecessor. Relatively good camera and playback equipment is inexpensive (beginning at under $3,000 for a portable camera, power supply and playback monitor). The medium is reusable. Videotape can be viewed immediately without development, erased, re-recorded and otherwise manipulated "on the spot". It can also be stored and reused over long periods of time. Moreover, the medium is electronically compatible with both broadcast and cable television systems without conversion. It can be used very effectively to record phenomena for later editing and viewing. It is basically a passive (non-interactive) medium. However, there are some educational principles for which the medium is particularly suitable.

Enlarging the Audience for Special Material. Video technology offers the opportunity to dramatically enlarge the audience for some material which otherwise requires impractical or prohibitively expensive delivery techniques. For example, the Harvard Dental School has developed and continues to develop videotape materials demonstrating procedures in dentistry and oral surgery. The use of the technology has inherent advantages over traditional methods. First, the material is highly visual. Second, it is very difficult for a large group of students to view a procedure being executed inside a patient's mouth. A small television camera can be maneuvered for close-in shots to provide a much better view of the operation. Using color equipment there is little loss in the true representation of the physical activity involved. The videotapes are then shown to groups of students with a teacher present

for commentary and for questions. These tapes are also used for distribution in the northeastern United States for dentists to be updated on new procedures and techniques. Each tape as it is viewed is described by an individual instructor familiar with the procedure. By using electronic editing techniques, the procedure can be compressed into a relatively small time unit even if the actual procedure required (for patient comfort, etc.) several hours or perhaps several patient visits to the dental clinic. In other similar cases, Medical Schools have recently begun to videotape surgical procedures as a regular part of instructional technique.

By editing carefully the videotapes of actual medical and dental procedures, the audience can be broadened in such a way that the number of "live" procedures in which the student participates can be reduced in some cases. The alternative is more teachers, more patients, and more interference with the process. For some complex and rare procedures, the alternative may be no demonstrative student teaching at all.

Making Available Inaccessible Material. As a close corollary to the wider distribution of material, video technology also enables the use of material in a classroom situation which is otherwise inaccessible or impractical. For example, Professor Gary Bellow in the Harvard Law School uses videotape to illustrate the lawyer's function in a variety of situations in a course called "The Lawyering Process". With the assistance of an actor and a practicing attorney, he is able to recreate and record scenes which can be used to examine varieties in approach to various courtroom situations. Videotapes of actual trials can also be used. By using the videotape as a lecture supplement, Professor Bellow is able to stop the tape at strategic points and engage the students in a discussion of alternative actions on the part of the lawyer. Resuming the tape playback allows the demonstrative and interactive process to continue.

John Austin (Harvard Business School and EDUCOM) has used videotape to develop "videocases" for a seminar in computer based information systems. The videocases are used to present an eyewitness chronicle of phenomena which occur during the complete life cycle of a management information system in a company. These cases are striking in their ability to communicate material that is virtually impossible to capture otherwise...the "body language" communicated by a corporate vice president as he is probed about the benefits of the new computer based MIS... the chaotic environment of a factory production line into which a process control computer is about to be introduced.

This type of material is simply inaccessable to students unless it can be experienced directly. Moreover, the use of the videotape medium prepares the student in a unique and pedagogically controllable way for the real experience.

Performing Self Analysis and Evaluation. The videotape medium is particularly useful in recording the behavior of an individual for self analysis and evaluation. The recording is immediately available for viewing. The recording tape can be erased and reused. For example, the technique is such in marketing to have students evaluate themselves in a "sales call" situation. Recordings of actual sales calls are used for demonstrative and comparative purposes. Videotape is used to record student role-playing in lawyer/client relationships in a legal practice course. Also videotape is used in Law Schools to record students performing as trial advocates for for self-evaluation and critiquing.

As a final example, videotape is being used to record the performance of teaching fellows in the classroom for self-evaluation and improvement. This technique is a significant part of an experiment at Harvard in the teaching of Economics 10, one of the largest courses at the University. One of the unexpected benefits is that the teaching fellows have begun to include the videotapes of their teaching performances as a part of their curriculum vitae for teaching positions with marked success.

Computer-based Modules

Computer technology inherently offers a more active role in the learning process. Through the use of the stored program property of computer systems, software can be developed to respond in logically different sequences depending on the inputs received. Sophisticated computer terminal equipment with keyboards, electrostatic pens, touchpads and the like allow a variety of input forms. Moreover, terminal equipment can also incorporate TV tubes, typing devices, film projectors and other output devices which operate under control of the stored program software. Communications technology now allows such terminals to be located from a few feet to thousands of miles from the computer system. Multiplexing techniques allow a large number of terminals (and users) to share a computer system resource (software and hardware). Commercial communications networks which can connect computer systems nationwide and worldwide pose a potential for large-scale sharing of computer resources (both programs and data).

The combination of these developments may improve the likelihood for a greater role for computer and video technology in instruction. It may also enable a more widespread application of educational principles which on a small scale would be too expensive. Much like manuscripts were inordinately expensive and inaccessible prior to printing technology.

The potential for combining some forms of visual media with computer systems can expand the effectiveness of video materials. In fact, there are three specific benefits of computer technology which video materials can share.

Interactive Testing of Accumulated Knowledge. A set of exercises in qualitative organic analysis has been implemented using the PLATO system by Harvard Professor Frank Westheimer in conjunction with Stanley Smith at the University of Illinois. These exercises involve the direct and independent interaction of individual students with the system in a technique which challenges the student's ability to assimilate and investigate organic chemical analyses as in sophisticated laboratory experiments. For example, such an experiment might be initiated by the challenge to the student "I am thinking of a certain chemical compound...". During the interaction, the computer-based system can respond to inquiries such as "Is the compound soluble in hydrochloric acid?". Through the use of the video capabilities of the slide projector built into the plasma tube PLATO terminal the system can also respond to "May I see an NMR spectrum of the compound?" or "What is the IR spectrum of the compound?" This application, in which visual material is closely integrated with computer technology, provides a powerful new teaching tool.

A different perspective of the same principle is offered in the use of computer-aided teaching outside the quantitative disciplines. Several Law teachers led by Harvard Professor Robert Keaton have developed an experimental program of computer-based exercises in law. The material has been developed in conjunction with Dr. Russell Burris, Chairman of the Consulting Group on

Instructional Design at the University of Minnesota and Professor Roger Park, of the University of Minnesota Law School. The material is a set of computerized simulation exercises in which the student assumes various roles and is asked to respond on a computer terminal to problems of the type one might confront in the representation of an actual legal situation. For example, in one case the student is placed in the role of trial advocate and is asked (by a program controlled computer terminal) to respond to problems of the type one might confront in a rapresentation of actual clients eithar in a clinical program or in privata practice. In another a serias of problems on evidence designed for use by first year studenta in civil procedure. This exercise places a student in the role of judge and requires the student to make rulings on objections and thereafter to identify reasons for the rulings. This material has evolved from lawyers, judgea, and other law teachers who have actually used the material themselves. The simulation modal is heuristic in the sense that responses are recorded so that future users can observe from aggregated statistics the responses of prior participants in the simulation game.

These computer-based exercises are used as adjunct material for courses in Law in a manner analogoua to the videotapes previously mentioned. However, in this case they ara not integrated modules like the PLATO-based chemistry material. The computer-based exercises and the videotapes are simply used to supplement the traditional case method of law teaching.

Hence the combination of printed case material, the videotapes, and the computer based exercises form a "package" from which individual teachers can choose to develop a course.

Self-paced Analysis and Investigation. A number of disciplines can make use of computer systems to enable individual students to perform analyses and investigations of various types. In the applied sciences, the computer used in this manner has become a virtual laboratory instrument. There is growing evidence that a computer used to implement a self-paced investigative analysis can provide a new and different representation of material to the students in other disciplines as well.

In economics, for example a computer-based model is used in the teaching of general equilibrium theory in economics. The model, implemented as a set of nine computer programs, can be operated interactively from a "hands-on" terminal and is designed as a set of self-paced and self-sufficient routines. In a paper describing this work,[5] Professor Richard Zeckhauser and two colleagues indicate that "limited experience with this experiment suggest that there may be substantial benefits beyond the improved pedagogy which we sought". The benefits perceived include: the ability for students with diverse levels of preparation to be taught a common body of material in a self-paced, skip-sections format; a new perspective to students who are already familiar with general equilibrium analysis; and, finally, a potentially effective instructional method assuming that materials can be widely disseminated and utilized by a large number of students. This work is one of 32 different experiences in computer-aided teaching in Economics described in the survey by Professor John C. Soper at Northern Illinois University.[6]

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5. Zeckhauser, R., Memishian, P. and Shemo, T., "General Equilibrium, A Computation Technique for Learning", HIER, Discussion Paper No. 311, August 1973.

6. Soper, John C., "Computer-Assisted Instruction in Economics: A Survey", July 1974.

In another experiment, a computer graphics system, devaloped originally for research in quantitative chemiatry, is being used as an undergraduate teaching device. This system, developed by Profeasor E.J. Corey, allows a chemistry student to make a thorough and sophisticated analysis of molecular structure. The synthesis of such complex organic structures usually requires a considerable number of discrete steps consisting of individual chemical reactions which together form a synthetic pathway. Structures of up to 75 atoms (not including hydrogen) may be entered into the system using a graphics (CRT) terminal with keyboard and electrostatic writing tablet. Significant chemical features are perceived and logical search processes are conducted by the system interacting with the student to find suitable chemical reactions for the assembly of the structure.

Gaming. The ability of computer-based software to store and manipulate data as well as interact with people in a number of "people oriented" ways enables the development of relatively complex games which can be used by students to play realistic roles in a simulated "real world" environment. The urban simulation game APEX has been used extensively to enable students to play the roles of urban decision makers interacting with each other about a simulated city. APEX simulates the city of Lansing, Michigan, and enables players to assume the roles of politicians, planners, developers, industrialists, and pollution control officers. The game is played in cycles which require each of the decision makers to input decisions about land development, industrial zoning, pollution regulations and the like. Players are required to negotiate with their colleagues in various roles during the decision process. The decisions are input to the computer-based game and the results for the simulated year are returned (in a few minutes) to each player telling what had happened for the city, each business, political fortunes and the state changes for each player and the city. In a paper describing the experience, one professor concludes that "...[it] promises a way of relating specific legal questions to the entire urban process - a way not dependent upon appellate cases but closely resembling the law's actual functioning on a number of levels ... [it] engages the players in decision-making and action in what Aristotle called the exercise of practical reason."[7]

In numerous Business Schools, "business games" are played competitively by individuals and teams of students in order to test business decision-making skills. Students play the role of corporate executives through a compressed series of quarterly and annual business decisions. Financial reports and other reflections of corporate status are printed by the computer system for each

7. Degnan, D. A. and Haar, C. M., "Computer Simulation in Urban Legal Studies," Journal of Legal Education, AALS, Vol. 23, 1970-71.

decision-making cycle of the game. The students, representing the corporate executives, are required to work individually and as a team in the simulated environment of competitive business.

Video materials assume several roles in these games. First, videotapes are used in some cases to present the basic situation which is being gamed. The conditions in particular parts of a city can often be represented visually with more affect than any other way, for example. Second, visual materials (although not videotape) are presented in the form of sophisticated graphics to represent outcomes of population shifts, economic factors, and the like. Third, videotapes of the games are very useful in a post mortem analysis and critique by the players as well as for introducing new players to the games.

The use of games allows heuristic processes which can, depending on the validity of the simulation, represent a cyclic but decision dependent process. These games require students to use accumulated knowledge to make critical decisions and also to interact in the decision process with other players.

SOME OBSTACLES TO CHANGE

Having argued for the opportunities of instructional technology and supported the argument with a few illustrations, pragmatism demands some treatment of the odds for changes in the instructional process. As predicted, the use of instructional technology continues to be in the category of "experimentation and development". However, the experimentation has already demonstrated some advantages of modules of technology-based teaching materials, if less clearly the role of "complete" technology-based courses. At issue is the role of technology in the improvement of the process which is demanding that more material be delivered to students in less time and at less cost. There are several areas in which some "breakthroughs" must occur before we can even move into the Carnegie Commission's category of "generally introduced" not to mention the advanced state of "generally in use".

Distribution and Access. There is a noticeable absence of a viable industry for the distribution of technology-based teaching materials. As a result, the materials are largely developed and used in a sort of "cottage industry" which centers around good technological facilities and highly motivated people working mostly in universities and colleges. There appear to be several established areas that must change as a prerequisite to any improvement. First, the book publishing industry must recognize and accept the market for technology-based supplements to printed material. Audiotapes and film strips have only a foot in the door. Computer programs are taboo. Second, libraries will have to accommodate the facilities for patrons to access the technology-based materials. The libraries, now squeezed by both the double digit inflation affecting printed materials for several successive

years (and no relief in sight) and the effect of personal income growth on their labor-intensive operations are seeking relief. However, gearing up to handle technology-based materials will undoubtedly aggravate the short term financial problem before making any contribution to the long term solution. Third, a national copyright and patent policy that motivates the development of technology-based materials without exacerbating the legal and financial problems of its use will be necessary. A good solution to this problem would do much to solve the first problem cited. A bad solution would virtually prevent any progress. Fourth, a methodology for distributing computer based material nationally is needed. Television and videotape equipment is sufficiantly standard (and relatively simple) that compatibility is not the major problem that it is in computer technology. The videodisc may solve the debilitating problem of the cost of the medium which has plagued videotape. Computer technology, however, has a major problem represented by the barriers to transportability of computer program material. Sophisticated communication networks may offer a solution, particularly if distance independent pricing and low fixed cost can become widespread. If the cost/performance of communication is right, the facilitating services required to interface students and teachers to multiple remote computer resources can probably be developed.

Adequate Technological Resources. Many schools have limited technological resources. Television playback equipment and computers have been beyond their economic reach. The videodisc may help with pure video presentations. The new "intelligent terminals" (which incorporate microcomputer technology) and low cost minicomputers may be usable in combination with communication networks and larger computers to bring technology-based instructional materials within the reach of many. This kind of technological

resource system would represent not only a basis for development of materials but also a large volume market for technology-based materials.

Rewarding Authorship. The individual efforts of authors in the development of technology-based teaching materials must be encouraged by incentives. The incentives must combine professional recognition with the potential for economic reward. Unfortunately, both elements of the reward structure are currently lacking. For example, junior faculty who devote substantial time to the development of technology-based teaching materials often do so at the expense of research and thus promotion. For most disciplines, the development of computer algorithms or video presentations carries nowhere near the professional weight of a published (printed) journal article. This discourages all but the most persistent. Moreover, the condition is improving only very slowly. The financial reward structure is equally discouraging. For financial reward, one writes books, not computer programs or video productions. Perhaps this problem will also be overcome given time and the appropriate combination of solutions to the previously described problems.

EDUCOM's Approach

EDUCOM was established in 1964 for the purpose of fostering the development of sharable technological resources in education. It has been through several cycles of hope and expectation. In 1972, EDUCOM began to develop the idea of a Planning Council for Computing in Higher Education and Research, an idea conceived from the NSF-sponsored seminars on computer networking held at Airlie House. This idea has now been transformed into an action-oriented group of twenty-two institutions that have committed money and time for a five year period to provide a "critical mass" for the development of national computer networking.[8] The EDUCOM Planning Council is directed by James Emery and is governed by a Policy Board composed of senior university executives and a Technical Committee composed of senior computer scientist/administrators from the twenty-two member schools. Supporting grants have been received from the Carnegie Corporation, the Exxon Educational Foundation and the Ford Foundation. The Planning Council focuses its attention on three interrelated areas:

1. Investigating the means for creating a national computer network. This started with the preparation of a plan laying out the steps needed to move from today's fragmented, ad hoc approach to a more coherent scheme for cooperation in the sharing of computer-based resources. A prototype national network activity has already started between the Planning Council institutions with the objective of conducting carefully developed and evaluated small-scale experiments in national networking. In addition, discipline group networking experiments are being developed

8. Emery, James C., "Implementation of a Facilitating Network" Policies, Strategies and Plans for Computing in Higher Ed., EDUCOM, Princeton, N.J. 1976

with the sponsorship and assistance of the Planning Council. These experiments, which are developed independently by teachers and researchers from various academic disciplines, are designed to evaluate the viability of distributing and accessing modular computer-based material via a national network.

2. Providing information to improve computing services within individual universities and colleges. Each institution must make its own decisions about computing and related resources. The studies and evaluations of the Planning Council will help to focus and identify both the costs and the benefits of available alternatives and will also provide some comparative data to aid institutions in finding more effective solutions.
3. Providing a means by which higher education can speak to the Federal Government on issues related to educational computing. Questions of regulatory and tax policy, costing and charging for computing services, the required use of Federally owned computers and the amount and method of providing financial support for educational computing are all matters that are being given attention.

With NSF support, EDUCOM is also developing a research tool for evaluating the role and scope of networking as well as the transitional effects for individual institutions (economic, behavioral, technological, and policy alternatives). This network simulation and gaming project will over the next two years, develop and validate a computer-based model of networking for use by educational institutions. The project involves

sixteen institutions, large and small, who are providing data and expertise to develop, validate, and test the model and the game. With the completed model, we will be able to examine the alternatives for the widespread use of computer-based instructional modules via networking, among other phenomena. It is conceivable, perhaps even likely, that the model could be adapted to the network distribution of video material when and if that analysis is useful.

As EDUCOM moves to test the notion of "technological publishing" it is our intention to include video material where it fits well with computer-based modules. If our experience to date is prophetic, the opportunities for such instructional packages are numerous.